

### REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 to 12 in the underlying PCT Application No. PCT/EP2004/011535 and adds new claims 13 to 29. The new claims, inter alia, conform the claims to United States Patent and Trademark Office rules and does not add any new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to United States Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/EP2004/011535 includes an International Search Report, dated February 4, 2005, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

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## OCCUPANT PROTECTION SYSTEM FOR A MOTOR VEHICLE

## Description

**FIELD OF THE INVENTION**

The present invention relates to an occupant protection system for a motor vehicle. Such an occupant protection system may  
5 include an airbag and/or a belt tensioner.

**BACKGROUND INFORMATION**

Airbag systems are ~~disclosed~~ **described**, for example, in the article "Hardware and Mechanics of Real Airbag Control  
10 Systems" published on the Internet page [www.informatik.uni-dortmund.de/airbag/seminarphase/hardware\\_vortrag.pdf](http://www.informatik.uni-dortmund.de/airbag/seminarphase/hardware_vortrag.pdf).

U.S. **Patent No.** 5,583,771, U.S. **Patent No.** 5,684,701 and U.S. **Patent No.** 6,532,508 [[B1]] describe the triggering of an  
15 airbag by a neural network as a function of an output signal of an acceleration sensor.

[[DE]] **German Published Patent Application No.** 198 54 380  
[[A1]] describes a method for detecting the severity of a  
20 vehicle collision, where the output signals of a plurality of acceleration sensors are supplied to a neural network. In the method, the start of the evaluation of the acceleration-sensor output signals is determined by a trigger signal, which is output by an acceleration sensor when its output signal exceeds  
25 a predefined threshold value. This acceleration sensor causes the other acceleration sensors to supply the specific output signal at one and the same time. It is also provided that the output signals of the acceleration sensors be integrated one or two times.

30

[[DE]] **German Published Patent Application No.** 100 35 505

[[A1]] describes a method, in which the future time

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characteristic of the output signal of an acceleration sensor is predicted with the aid of a neural network on the basis of the acceleration-sensor signals at at least one defined time.

5    [[DE]] German Published Patent Application No. 100 40 111  
[[Al]] describes a method for producing a triggering decision for restraining devices in a vehicle, where the difference of measured acceleration values is calculated and the magnitude of the difference is subsequently integrated. The integral is  
10 compared to at least one threshold value. If the integral does not exceed this threshold value by a predefined time, then the position of a triggering threshold for the measured acceleration or for a speed change derived from it is modified in such a manner, that the triggering sensitivity becomes  
15 lower.

Described in [[DE]] German Published Patent Application No. 101 03 661 [[Cl]] is a method for sensing lateral impact in a motor vehicle; acceleration sensors, from whose output signals  
20 the difference is calculated, being situated on the left and right sides of the vehicle. The differential acceleration signal is integrated or summed up. For the purpose of side-impact sensing, the differential speed signal is compared to a threshold value, which is calculated as a function of the  
25 differential acceleration signal.

#### SUMMARY

The object Example embodiments of the present invention is to may provide an improved occupant protection system systems for  
30 a motor vehicle, in particular e.g., an occupant protection system including an airbag and/or a belt tensioner. In so doing, it is particularly desirable may be provided for the triggering of such an occupant protection system for a motor vehicle to be especially particularly precise.

35

~~The above mentioned object is achieved by an~~ **An** occupant protection system for a motor vehicle ~~having~~ **may include** at least one crash sensor for measuring a motion variable of the motor vehicle, the occupant protection system including an  
5 occupant protection device controllable via an ignition signal, and a control unit for ascertaining or generating the ignition signal as a function of a time average, over at least a first time interval, of the motion variable measured by the crash sensor, and, ~~advantageously~~ **e.g.**, as a function of a  
10 time average of the motion variable measured by the crash sensor, over a second time interval different from the first time interval.

An occupant protection device within the ~~meaning of the~~  
15 ~~present invention is, in particular,~~ **present context may include, e.g.,** an airbag and/or a belt tensioner.

An average value within the ~~meaning of the present invention~~ **present context** may be an arithmetic mean or a weighted  
20 average. In the case of such a weighted average, e.g., more recent values of the motion variable in the relevant time interval may be more heavily weighted than older values of the motion variable in the relevant time interval. An average value within the ~~meaning of the present invention~~ **present**  
25 **context** may also be a value proportional to an average value. ~~In an advantageous refinement of the present invention, the~~ **The** average value ~~[[is]]~~ **may be** a value proportional to the arithmetic mean. In this context, the average value ~~is~~ **advantageously** **may be** a value proportional to the integral of  
30 the motion variable in the relevant time interval or the sum of sampled values of the motion variable in the relevant time interval.

A motion variable of the motor vehicle within the ~~meaning of~~  
35 ~~the present invention~~ **present context** may be an acceleration,

a speed, or a displacement, or a variable derived from one of these variables. In this context, the motion variable ~~is~~ advantageously may be an acceleration.

5 A crash sensor within the ~~meaning of the present invention~~ present context may be an acceleration sensor for measuring an acceleration in one or more directions. A crash sensor within the ~~meaning of the present invention~~ present context may also be a radar device, an infrared set-up, or a camera. In this  
10 case, a motion variable of the motor vehicle may be a distance of the motor vehicle from an obstacle, the first or second derivative of this distance, or another equivalent similar variable. A crash sensor within the ~~meaning of the present invention~~ present context may also be a sensor for measuring a  
15 deformation of the motor vehicle. Such a sensor may be a fiber-optic sensor or a sensor described in [[DE]] German Published Patent Application No. 100 16 142 [[Al]]. In this case, a motion variable of the motor vehicle may be a deformation of the motor vehicle, the first or second  
20 derivative of this deformation, or another equivalent similar variable.

An ignition signal within the ~~meaning of the present invention~~ present context may be a binary signal, which indicates if an  
25 occupant protection device, such as an airbag and/or a belt tensioner, should be triggered. Such an ignition signal within the ~~meaning of the present invention~~ present context may be a "FIRE/NO-FIRE" signal described in [[DE]] German Published Patent Application No. 100 35 505 [[Al]]. An  
30 ignition signal within the ~~meaning of the present invention~~ present context may also be a more complex signal, which indicates the degree (e.g., stage 1 or stage 2) to which an airbag should be fired. In addition, such an ignition signal within the ~~meaning of the present invention~~ present context  
35 may be a crash-severity parameter or an occupant acceleration

or loading described in ~~[[DE]]~~ German Published Patent Application No. 100 35 505 [[A1]]. An ignition signal within the ~~meaning of the present invention~~ present context may be, or include, an information item indicating the location and/or the direction of a collision.

~~Within the meaning of the present invention,~~ a A second time interval different from a first time interval may differ from the first time interval in its length and/or its position.

~~In a further advantageous refinement of the present invention,~~ the The ignition signal ~~[[is]]~~ may be ascertainable by the control unit as a function of time averages of the motion variable measured by the crash sensor in two to twenty, advantageously e.g., in two to ten, different time intervals.

~~In a further advantageous refinement of the present invention,~~ the The ignition signal ~~[[is]]~~ may be ascertainable by the control unit as a function of time averages of the motion variable measured by the crash sensor in two to five different time intervals. Different time intervals within the ~~meaning of the present invention~~ present context may differ from each other in the length and/or in the position.

~~In a further advantageous refinement of the present invention,~~ the The time intervals are may be between 1 ms and 200 ms long, ~~in particular~~ e.g., between 4 ms and 32 ms long, and advantageously, e.g., between 8 ms and 24 ms long. ~~In one refinement of the present invention,~~ the The time intervals are essentially may be the same length, or they may vary in length.

~~In a further advantageous refinement of the present invention,~~ at At least two, ~~in particular~~ e.g., adjacent, time intervals are may be staggered by between 1 ms and 50 ms, advantageously e.g., by between 2 ms and 16 ms. ~~In a further advantageous~~

~~refinement of the present invention, all~~ All adjacent time intervals are may each be offset from each other by between 1 ms and 50 ms, advantageously e.g., by between 2 ms and 16 ms.

5 ~~In a further advantageous refinement of the present invention,~~  
~~the~~ The occupant protection system ~~includes~~ may include at  
least one additional crash sensor for measuring a motion  
variable of the motor vehicle, the ignition signal also being  
ascertainable by the control unit as a function of at least  
10 one time average of the motion variable measured by the  
additional crash sensor over a time interval. ~~In a further~~  
~~advantageous refinement of the present invention, the~~ The  
additional crash sensor ~~[[is]]~~ may be positioned more than 0.5  
m away from the crash sensor mentioned at the outset.

15 ~~The above mentioned object is additionally achieved by~~ In a  
motor vehicle, ~~in particular~~ e.g., a motor vehicle including  
an occupant protection system that has one or more of the  
above-mentioned features, the motor vehicle ~~including~~ the  
20 motor vehicle may include at least one crash sensor for  
measuring a motion vehicle of the motor vehicle and an  
occupant protection device controllable via an ignition  
signal, the motor vehicle including a control unit for  
ascertaining or generating the ignition signal as a function  
25 of a time average of the motion variable measured by the crash  
sensor over at least one first time interval, and  
~~advantageously,~~ e.g., as a function of a second time interval  
of the motion variable measured by the crash sensor over a  
second time interval different from the first time interval.

30 ~~The above mentioned object is additionally achieved by~~ In a  
method for operating an occupant protection system for a motor  
vehicle, ~~in particular~~ e.g., by a method for operating an  
occupant protection system, having one or more of the above-  
35 mentioned features, the occupant protection system ~~including~~

includes an occupant protection device controllable via an ignition signal, and the ignition signal being ascertained as a function of a time average of a measured motion variable over at least one first time interval, and advantageously,  
5 e.g., as a function of a time average of the measured motion variable over a second time interval different from the first time interval.

A motor vehicle within the ~~meaning of the present invention is~~  
10 present context may include, in particular e.g., a land vehicle that may be used individually in road traffic. In particular For example, motor vehicles in the ~~sense of the present invention~~ present context are not restricted to land vehicles having an internal combustion engine.

15 Further advantages features and details ~~are derived from the following description of exemplary embodiments, objects that are identical or substantially identical being denoted by the same reference numerals. The figures show:~~ of the present  
20 invention are described in more detail below with reference to the appended Figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of a motor vehicle[[]].

25 Fig. 2 illustrates an exemplary embodiment of an occupant protection system[[]].

Fig. 3 illustrates an exemplary embodiment of a control  
30 module[[]].

Fig. 4 illustrates an exemplary embodiment of a triggering module[[]].



Fig. 5 illustrates an exemplary embodiment of an output signal of a crash sensor[[]].

Fig. 6 illustrates the integral of the output signal [[of]]  
5 illustrated in Fig. 5, in one time interval[[]].

Fig. 7 illustrates an exemplary embodiment of a neural network[[]].

10 Fig. 8 illustrates an exemplary embodiment of a decision tree[[]].

Fig. 9 illustrates an ~~a further~~ exemplary embodiment of a triggering module[[]].

15 Fig. 10 illustrates an ~~a further~~ exemplary embodiment of a triggering module, ~~and~~.

Fig. 11 illustrates an ~~a further~~ exemplary embodiment of a  
20 triggering module.

#### DETAILED DESCRIPTION

Fig. 1 ~~shows is~~ a plan view of a motor vehicle 1 having an occupant protection system, which is ~~represented~~ illustrated  
25 in Fig. 2 in the form of a block diagram. The occupant protection system includes at least an airbag 15, ~~which is not represented in Fig. 1 but in~~ see, e.g., Fig. 2, and/or a belt tensioner 16, ~~which is not represented in Fig. 1 but in~~ see, e.g., Fig. 2. The occupant protection system additionally  
30 includes a control unit 2 for triggering airbag 15 and/or belt tensioner 16, as well as a crash sensor S2 integrated into the right front end of motor vehicle 1 and a crash sensor S3 integrated into the left front end of motor vehicle 1. Crash sensors S2 and S3 are connected to control unit 2 by leads 5  
35 and 6.

Crash sensors S2 and S3, as well as an additional crash sensor S1 integrated into control unit 2, as ~~shown~~ illustrated in Fig. 2, may take the form of acceleration sensors in the present exemplary embodiment. Suitable acceleration sensors are described, for example, in chapter 3.2, 'Acceleration Sensor,' of the article "Hardware and Mechanics of Real Airbag Control Systems" published on the Internet page [www.informatik.uni-](http://www.informatik.uni-dortmund.de/airbag/seminarphase/hardware_vortrag.pdf)

[dortmund.de/airbag/seminarphase/hardware\\_vortrag.pdf](http://www.informatik.uni-dortmund.de/airbag/seminarphase/hardware_vortrag.pdf). Examples of suitable acceleration sensors include Bosch SMB060, Bosch PAS3 or Bosch UPF1. A suitable acceleration sensor may include, for example, a Bessel low-pass filter having a cutoff frequency of, e.g., 400 Hz. Crash sensors S1, S2, and S3 supply acceleration values aS1, aS2, and aS3, respectively, as output signals.

The occupant protection system additionally includes a belt sensor 11 for detecting if a seat belt is being used, and for outputting a corresponding belt information item MBELT. The occupant protection system further includes a seat-occupancy sensor 12 for detecting if, or how, a seat is occupied, and for outputting a corresponding seat-occupancy information item MSEAT. An example of a suitable seat-occupancy sensor is a pressure sensor integrated into the seat. Also suitable is an infrared scanning system described in chapter 3.3, "Interior Sensing," of the article "Hardware and Mechanics of Real Airbag Control Systems" published on the Internet page [www.informatik.uni-](http://www.informatik.uni-dortmund.de/airbag/seminarphase/hardware_vortrag.pdf)

[dortmund.de/airbag/seminarphase/hardware\\_vortrag.pdf](http://www.informatik.uni-dortmund.de/airbag/seminarphase/hardware_vortrag.pdf). Infrared scanning and fuzzy logic not only allow seat occupancy to be detected, but also allow a determination as to whether the seat occupant is an object, such as a purse, or a person. To this end, a line of, e.g., eight or more light-emitting diodes above the seat emit infrared light, and a CCD

matrix of 64 pixels records the scene illuminated in this manner. These charged coupled devices, abbreviated CCD, are made up of photodiodes and amplifier elements in matrix configurations. In this context, incident light releases  
5 charge carriers in each instance. A signal generated in this manner is amplified, processed, and stored. This procedure is repeated at different angles, and the seat is scanned in this manner. Image-processing algorithms and fuzzy-logic algorithms detect contours of objects and persons from these  
10 signals.

It may also be provided that the occupant-protection system include a control element 14 for activating or deactivating airbag 15. A corresponding switching signal is designated by  
15 reference character ONOFF.

Control unit 2 includes a control module 10 for calculating and outputting an ignition signal AIR for airbag 15 and/or an ignition signal BELT for belt tensioner 16 as a function of  
20 acceleration values aS1, aS2, and aS3, belt information item MBELT, seat-occupancy information item MSEAT, and switching signal ONOFF.

Fig. 3 ~~shows~~ illustrates an exemplary embodiment of control  
25 module 10. Control module 10 includes a triggering module 20 for calculating and outputting an ignition recommendation CRASH as a function of acceleration values aS1, aS2, and aS3. Control module 10 additionally includes a firing table 21 for calculating and outputting ignition signal AIR for airbag 15  
30 and/or ignition signal BELT for belt tensioner 16 as a function of ignition recommendation CRASH, belt information item MBELT, seat-occupancy information item MSEAT, and switching signal ONOFF. Thus, it may be provided that ignition signal AIR only be equal to ignition recommendation  
35 CRASH, when a corresponding seat is occupied by a person of a

specific size, and that ignition signal AIR otherwise be equal to 0.

Both ignition recommendation CRASH and ignition signals AIR  
5 and BELT may be ignition signals ~~within the meaning of the~~  
~~claims~~. Both ignition recommendation CRASH and ignition  
signals AIR and BELT may be a binary signal, e.g., in  
accordance with the "FIRE/NO-FIRE" signal described in [[DE]]  
German Published Patent Application No. 100 35 505 [[A1]],  
10 which indicates whether an occupant protection device, such as  
an airbag and/or a belt tensioner, should be triggered. Both  
ignition recommendation CRASH and ignition signals AIR and  
BELT may also be a more complex signal. Both ignition  
recommendation CRASH and ignition signal AIR may be, for  
15 example, a more complex signal which indicates the degree  
(e.g., stage 1 or stage 2) to which airbag 15 should be fired.  
Both ignition recommendation CRASH and ignition signal AIR may  
additionally include, for example, a crash-severity parameter  
described in [[DE]] German Published Patent Application No.  
20 100 35 505 [[A1]] or an occupant acceleration or occupant  
loading. It may be provided that both ignition recommendation  
CRASH and ignition signals AIR and BELT ~~can~~ may indicate the  
location and/or the direction of a collision.

25 Fig. 4 ~~shows~~ illustrates an exemplary embodiment of triggering  
module 20. Triggering module 20 includes an analog-to-digital  
converter 25 (analog-to-digital converter) for sampling  
acceleration value aS1 and outputting a sampled acceleration  
value as1, an analog-to-digital converter 26 for sampling  
30 acceleration value aS2 and outputting a sampled acceleration  
value as2, and an analog-to-digital converter 27 for sampling  
acceleration value aS3 and outputting a sampled acceleration  
value as3.

The sampling frequency of the  $\Delta t$  of analog-to-digital converters 25, 26, and 27 may be, for example, 4 kHz. Triggering module 20 additionally includes (digital) integrators 31, 32, 33, 34, 35, and 36.

5

Using integrator 31, a pseudospeed value  $v0S1$  at time  $t_0$  is ascertained according to

$$v0S1 = \int_{t_0 - \tau_0}^{t_0} as1 \cdot dt ,$$

where  $\tau_0$  is the length of a time interval  $[t_0 - \tau_0, t_0]$  or 40

10 (cf. Fig. 5). Time  $t_0$  designates the current time, i.e., the current value of time  $t$ .

Using integrator 32, a pseudospeed value  $v1S1$  at a time  $t_0 - \tau_1$  is ascertained according to

15 
$$v1S1 = \int_{t_0 - \tau_0 - \tau_1}^{t_0 - \tau_1} as1 \cdot dt .$$

Using integrator 33, a pseudospeed value  $v2S1$  at a time  $t_0 - \tau_2$  is ascertained according to

$$v2S1 = \int_{t_0 - \tau_0 - \tau_2}^{t_0 - \tau_2} as1 \cdot dt .$$

20

Using integrator 34, a pseudospeed value  $v3S1$  at a time  $t_0 - \tau_3$  is ascertained according to

$$v3S1 = \int_{t_0 - \tau_0 - \tau_3}^{t_0 - \tau_3} as1 \cdot dt .$$

25 Using integrator 35, a pseudospeed value  $v0S2$  at time  $t_0$  is ascertained according to

$$v0S2 = \int_{t_0 - \tau_0}^{t_0} as2 \cdot dt .$$

Using integrator 36, a pseudospeed value v0S3 at time t<sub>0</sub> is ascertained according to

$$v0S3 = \int_{t_0 - \tau_0}^{t_0} as3 \cdot dt .$$

5 Fig. 5 and Fig. 6 illustrate the effect of integrators 31, 32, 33, 34, 35, and 36. In this context, Fig. 5 ~~shows~~ illustrates an example of the curve of (sampled) acceleration value as1 versus time t in the event of a frontal collision of motor vehicle 1 with an obstacle. Fig. 6 ~~shows~~ illustrates an  
10 example of a curve of pseudospeed value v0S1 for  $\tau_0 = 24\text{ms}$ .

In the exemplary embodiment ~~shown~~ illustrated in Fig. 6,  $\tau_1$  is 17 ms,  $\tau_2$  is 34 ms, and  $\tau_3$  is 51 ms. ~~In one advantageous refinement,~~  $\tau_1$  may be 8 ms,  $\tau_2$  may be 16 ms, and  $\tau_3$  may be 24  
15 ms.

Pseudospeed values v0S1, v1S1, v2S1, v3S1, v0S2, and v0S3 are examples of time averages within the ~~meaning of the present invention~~ present context.

20 Triggering module 20 further includes a trigger generator 30 for generating trigger recommendation CRASH. Trigger generator 30 may take the form of a neural network, as ~~shown~~ illustrated in Fig. 7 in an exemplary embodiment.

25 The neural network ~~shown~~ illustrated in Fig. 7 includes six input nodes 50, 51, 52, 53, 54, 55, six covered nodes 60, 61, 62, 63, 64, 65, and an output node 70, each input node 50, 51, 52, 53, 54, 55 being connected to each covered node 60, 61, 62, 63, 64, 65, and each covered node 60, 61, 62, 63, 64, 65  
30 being connected to output node 70. In Fig. 7, however, not all of the connections between input nodes 50, 51, 52, 53, 54,

55 and covered nodes 60, 61, 62, 63, 64, 65 are ~~shown~~  
illustrated for reasons of clarity.

Pseudospeed value v0S1 is the input variable input into input  
5 node 50,

pseudospeed value v1S1 is the input variable input into input  
node 51,

pseudospeed value v2S1 is the input variable input into input  
node 52,

10 pseudospeed value v3S1 is the input variable input into input  
node 53,

pseudospeed value v0S2 is the input variable input into input  
node 54, and

15 pseudospeed value v0S3 is the input variable input into input  
node 55.

The output variable from output node 70 is ignition  
recommendation CRASH.

Details regarding neural networks may be found in U.S. Patent  
20 No. 5,583,771, U.S. Patent No. 5,684,701, and the documents  
"Techniques And Application Of Neural Networks", Taylor, M.  
and Lisboa, Ellis Horwood, West Sussex, England, 1993,  
"Naturally Intelligent Systems", Caudill, M. and Butler, G.,  
MIT Press, Cambridge, 1990, and "Digital Neural Networks",  
25 Kung, S. Y., PTR Prentice Hall, Englewood Cliffs, NJ, 1993,  
cited in U.S. 5,684,701.

Table 1

```

/* Evaluation function */
int evaluate_Action(double *x)
{
    int CRASH;

    if (v0S3 <  $\delta_{v0S3}$  ) {
        if (v0S2 <  $\delta_{v0S2}$  ) {
            if (v2S1 <  $\delta_{v2S1}$  ) {
                if (v0S1 <  $\delta_{v0S1}$  ) {
                    CRASH = 0;
                } else {
                    if (v0S3 <  $\delta_{v0S3,2}$  ) {
                        CRASH = 0;
                    } else {
                        if (v0S1 <  $\delta_{v0S1,2}$  ) {
                            if (v1S1 <  $\delta_{v1S1}$  ) {
                                CRASH = 1;
                            } else {
                                CRASH = 0;
                            }
                        } else {
                            CRASH = 1;
                        }
                    }
                }
            } else {
                if (v0S2 <  $\delta_{v0S2,2}$  ) {
                    CRASH = 0;
                } else {
                    if (v0S3 <  $\delta_{v0S3,3}$  ) {
                        CRASH = 0;
                    } else {
                        CRASH = 1;
                    }
                }
            }
        } else {
            CRASH = 1;
        }
    } else {
        CRASH = 1;
    }
    return (CRASH);
}

```

As an alternative, trigger generator 30 may take the form of a sequence of comparisons to limiting values. Table 1 ~~shows~~ illustrates such a sequence of comparisons to limiting values,



the code ~~shown~~ illustrated in Table 1 having been automatically generated by a learning process. For the code ~~shown~~ illustrated in Table 1,  $\tau_1$  is 4 ms,  $\tau_2$  is 8 ms, and  $\tau_0$  is 24 ms.

5

Fig. 8 ~~shows~~ illustrates the code of Table 1 represented as a decision tree 80. In this context, reference numeral 81 denotes the inquiry as to whether  $v0S3$  is less than a limiting value  $\delta_{v0S3}$ .

10 Reference numeral 82 denotes the inquiry as to whether  $v0S2$  is less than a limiting value  $\delta_{v0S2}$ .

Reference numeral 83 denotes the inquiry as to whether  $v2S1$  is less than a limiting value  $\delta_{v2S1}$ .

15 Reference numeral 84 denotes the inquiry as to whether  $v0S1$  is less than a limiting value  $\delta_{v0S1}$ .

Reference numeral 85 denotes the inquiry as to whether  $v0S3$  is less than a limiting value  $\delta_{v0S3,2}$ .

Reference numeral 86 denotes the inquiry as to whether  $v0S1$  is less than a limiting value  $\delta_{v0S1,2}$ .

20 Reference numeral 87 denotes the inquiry as to whether  $v1S1$  is less than a limiting value  $\delta_{v1S1}$ .

Reference numeral 88 denotes the inquiry as to whether  $v0S2$  is less than a limiting value  $\delta_{v0S2,2}$ .

25 Reference numeral 89 denotes the inquiry as to whether  $v0S3$  is less than a limiting value  $\delta_{v0S3,3}$ .

~~According to~~ As illustrated in Fig. 8 and Table 1, trigger generator 30 disregards pseudospeed value  $v3S1$ . This is taken into account in the learning process, but is disregarded by  
30 the learning algorithm for generating the code according to Table 1.

Fig. 9 ~~shows~~ illustrates an exemplary embodiment of a triggering module 120 that is an alternative to triggering  
35 module 20. In this context, integrators 32, 33, and 34 are

replaced by lag elements 132, 133, and 134, which are positioned ~~[[in]] such a manner,~~ that pseudospeed value v1S1 results as pseudospeed value v0S1 delayed by time  $\tau_1$ , pseudospeed value v2S1 results as pseudospeed value v0S1  
5 delayed by time  $\tau_2$ , and pseudospeed value v3S1 results as pseudospeed value v0S1 delayed by time  $\tau_3$ .

One example of a possible (simple) implementation of integrator 31 (and appropriately adapted for integrators 32,  
10 33, and 34) is

$$vS1(i) = c \cdot \Delta t \sum_{j=i-\frac{\tau_0}{\Delta t}}^i as1(j),$$

where i is a running index for specifying current time  $t_0$  and is a constant. In this case, pseudospeed values v0S1, v1S1, v2S1, and v3S1 are yielded, for example, in accordance with  
15 the following relationships:

$$v0S1 = vS1(i)$$

$$v1S1 = vS1\left(i - \frac{\tau_1}{\Delta t}\right)$$

$$20 \quad v2S1 = vS1\left(i - \frac{\tau_2}{\Delta t}\right)$$

$$v3S1 = vS1\left(i - \frac{\tau_3}{\Delta t}\right)$$

Fig. 10 ~~shows~~ illustrates an exemplary embodiment of a  
25 triggering module 220 that is an alternative to triggering module 20. In this context, integrators 32, 33, and 34 are replaced by integrators 232, 233, and 234. In this context, pseudospeed value v1S1 is ascertained via integrator 232 according to

$$v1S1 = \int_{t_0-\tau_1}^{t_0} as1 \cdot dt .$$

Using integrator 233, a pseudospeed value v2S1 at time t<sub>0</sub> is ascertained according to

5 
$$v2S1 = \int_{t_0-\tau_2}^{t_0} as1 \cdot dt .$$

Using integrator 234, a pseudospeed value v3S1 at a time t<sub>0</sub> is ascertained according to

$$v3S1 = \int_{t_0-\tau_3}^{t_0} as1 \cdot dt .$$

10

In triggering module 20 ~~according to~~ illustrated in Fig. 4 and triggering module 120 ~~according to~~ illustrated in Fig. 9, the time intervals differ in their position. However, in triggering module 220 ~~according to~~ illustrated Fig. 10, the

15 time intervals differ in their length. It may also be provided that time intervals differ in their length and in their position. A corresponding exemplary embodiment is ~~shown~~ illustrated in Fig. 11. Fig. 11 ~~shows~~ illustrates an exemplary embodiment of a triggering module 320 that is an

20 alternative to triggering module 220. In this context, integrator 234 is replaced by an integrator 334, with the aid of which a pseudospeed value v3S1 at a time t<sub>0</sub>-τ<sub>4</sub> is ascertained according to

$$v3S1 = \int_{t_0-\tau_3-\tau_4}^{t_0-\tau_4} as1 \cdot dt .$$

25

~~In particular~~ For example, in connection with neural networks, automatically generated decision trees, or comparable, learning, evaluation procedures, ~~the present invention produces especially~~ particularly robust control of airbags and

30 belt tensioners may be provided.

Although explained in the exemplary embodiments in view of airbags and belt tensioners for a frontal collision, the ~~present invention~~ foregoing should not, ~~of course,~~ be

5 considered to be restricted ~~to this case~~. The Example embodiments of the present invention ~~[[is]]~~ are also applicable to side airbags and other occupant protection systems. In one implementation for side airbags, crash sensors S2 and S3 may be ~~situated~~ arranged, for example, in

10 the B-pillar. It may be provided that at least one pseudospeed value over at least one additional time interval be calculated for crash sensor S2 and/or crash sensor S3, as well.

15 A control unit within the ~~meaning of the present invention~~ present context may also be a distributed system. A control unit within the ~~meaning of the present invention~~ present context does not have to be accommodated in a single housing. A control unit within the ~~meaning of the present invention~~

20 present context may also be an individual chip or a printed circuit board.

To the extent that decision trees are mentioned in connection with the generation of ignition recommendation CRASH, these

25 may also be replaced by regression trees, association tables, rule sets, supervector machines, or other machine-learning procedures, etc.

Instead of motion variables or their average values,

30 differences of motion variables, average values of these differences, and/or differences of average values may also be used. Thus, e.g., a subtractor may be provided in front of integrators 31, 32, 33, 34, 35, 36, 232, 233, 234, and 334

illustrated in Fig. 4, Fig. 9, Fig. 10, and/or Fig. 11, so

35 that instead of sampled acceleration values as1, as2, as3,

differential values  $\Delta as1$ ,  $\Delta as2$ ,  $\Delta as3$  are input variables of integrators 31, 32, 33, 34, 35, 36, 232, 233, 234, and 334,  $\Delta as1$  being equal to difference  $as1-as2$ ,  $\Delta as2$  being equal to difference  $as1-as3$ , and  $\Delta as3$  being equal to difference  
5  $as2-as3$ . In addition, it may be provided that differential value  $\Delta as1$  be processed in the same manner as sampled acceleration value  $as1$  illustrated in Fig. 4, Fig. 9, Fig. 10, and/or Fig. 11, that differential value  $\Delta as2$  be processed in the same manner as sampled acceleration value  $as1$  illustrated  
10 in Fig. 4, Fig. 9, Fig. 10, and/or Fig. 11, and/or that differential value  $\Delta as3$  be processed in the same manner as sampled acceleration value  $as2$  illustrated in Fig. 4, Fig. 9, Fig. 10, and/or Fig. 11. In this case, the number of integrators and the number of input variables are to be  
15 appropriately adapted to trigger generator 30.

Differences may also be time differences. Thus, it may be provided that differential values  $\Delta as1$ ,  $\Delta as2$ ,  $\Delta as3$  be used in place of sampled acceleration values  $as1$ ,  $as2$ ,  $as3$  as input  
20 variables of integrators 31, 32, 33, 34, 35, 36, 232, 233, 234, and 334,  $\Delta as1(t)$  being equal to difference  $as1(t)-as1(t-\tau)$ ,  $\Delta as2$  being equal to difference  $as2(t)-as2(t-\tau)$  or difference  $as2(t)-as3(t-\tau)$ , and  $\Delta as3$  being equal to difference  $as3(t)-as3(t-\tau)$  or difference  
25  $as3(t)-as2(t-\tau)$ .

In accordance with above-mentioned variants with regard to the calculation of a difference, motion variables within the ~~meaning of the present invention~~ present context may also be  
30 differences of motion variables, when they are used as input variables.

One may proceed with pseudospeed values  $v0S1$ ,  $v1S1$ ,  $v2S1$ ,  $v3S1$ ,  $v0S2$ ,  $v0S3$  in an analogous manner. Accordingly, average  
35 values of motion variables within the ~~meaning of the present~~

~~invention~~ present context may also be differences of average values of motion variables or average values of differences of motion variables, when they are used as input variables.

~~List of Reference Numerals~~

**LIST OF REFERENCE NUMERALS**

	1	motor vehicle
	2	control device
5	5, 6	leads
	10	control module
	11	belt sensor
	12	seat-occupancy sensor
	14	control element
10	15	airbag
	16	belt tensioner
	20, 120, 220, 320	triggering module
	21	firing table
	25, 26, 27	analog-to-digital converter
15	30	trigger generator
	31, 32, 33, 34,	
	35, 36, 232, 233,	
	234, 334	integrator
	40	time interval
20	50, 51, 52, 53,	
	54, 55	input node
	60, 61, 62, 63	
	64, 65	covered node
	70	output node
25	80	decision tree
	81, 82, 83, 84,	
	85, 86, 87, 88,	
	89	inquiry
	132, 133, 134	lag element
30	AIR, BELT	ignition signal
	aS1, aS2, aS3,	
	as1, as2, as3	acceleration value
	CRASH	ignition recommendation
	ONOFF	switching signal
35	MBELT	belt information

MSEAT	seat-occupancy information
S1, S2, S3	crash sensor
t	time
t0	current time
5 v0S1, v1S1, v2S1,	
v3S1, v0S2, v0S3	pseudospeed value
$\tau_0, \tau_1, \tau_2, \tau_3$	length of a time interval



# ABSTRACT

5 An occupant protection system for a motor vehicle includes at least one crash sensor for measuring a motion variable. The occupant protection system includes an occupant protection device, controlled by an ignition signal, and a control device for determining the ignition signal subject to an average time value of the motion variable measured by the crash sensor during at least one first time interval.